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Sustainable Commercial Building Utilization by Efficient Electricity and Water Consumption

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Abstract

In developing nations such as Bangladesh, an abundance of energy use may result in a dearth of energy sources. Alternative methods must be employed to reduce these uses for a better tomorrow. A commercial structure in Dakbanglo, Khulna, Bangladesh, can be used to illustrate the implementation of initiatives. As one of the hottest cities in Bangladesh, Khulna necessitates the use of cooling energy for people to be able to focus on their work. Concrete walls prevent natural light from penetrating most buildings. As a result, a glass wall will reduce energy consumption by allowing sufficient light and air to enter. The following concern is water, which requires substantial energy to pump and treat. In this circumstance, we can devise a workaround by avoiding the use of electricity. These alternatives may have a high initial cost, but their B/C ratio makes them effective. It will reduce energy costs by approximately 15%. This paper shows ways to reduce the cost of alternative energy sources. These ideas can be extended to other buildings to reduce traditional energy use.

Keywords: *sustainable commercial building, solar energy, B/C ratio, electricity, energy efficiency.*

1 Introduction

The modern energy consumption mindset is "as much as we want, whenever we want”. This argument claims world consumption is at a historic low. Bangladesh faces a severe energy shortage. Urbanization has increased commercial building energy use. Green construction approaches lower a structure's carbon footprint and boost energy efficiency; therefore it makes sense. Long-term infrastructure sustainability demands environmental, social, and economic progress.
Sustainable construction aims to achieve several things, including:

- Efficient use of resources
- Efficiency in energy use
- The end of pollution in natural areas
- Coordination with the natural world
- Systematic and methodical approaches (OECD, 2004)

For sustainable construction and environmental improvement, these elements must be present. Global metropolitan areas have 400 big cities and 23 megacities with populations of one to 10 million. Cities use 60% to 80% of the world's energy despite covering only 2% of the land. Urban populations rose from 220 million to over 2.8 billion in the 20th century and are expected to reach 6.9 billion by 2050, or 70% of the world's population. (Sodiq et al., 2019).

A qualitative sustainability assessment will focus on the building's energy and water efficiency. Because buildings require energy throughout their lifespan, energy efficiency reduces energy consumption and carbon emissions. Commercial buildings need more energy during business hours to produce. Since environmentally friendly construction methods have advanced, this essay concentrates on the existing building. More than 40% of construction energy demand will rise in 20 years. Buildings use electricity as their main energy source, and demand is rising. Plans to boost building energy efficiency are needed to mitigate escalating demand. (Mariano-Hernández et al., 2021).

HVAC, lighting, and other running services consume 80% of the total energy consumed by a building over its lifetime (Juan & Gao, 2010). To achieve the goal of a sustainable commercial building, energy, resources, and water must be used efficiently. Energy efficiency can be improved by utilizing particular elements such as adequate sunshine exposure and a ventilation system that allows for adequate air circulation. The already precarious scenario could worsen if individuals consume more water than they need, necessitating increased energy consumption. Human activities such as urbanization and population increase are putting a strain on groundwater.

Renewable energy sources such as solar, wind, and water current are the best alternatives to non-renewable sources for effective energy utilization. Although these materials are abundant in nature, obtaining and storing them can be challenging. Heat and electricity storage systems have a significant impact on the continued decline of fossil fuels and the rapid expansion of renewable energy sources. The rise in renewable resources and fall in fossil fuel usage is attributed to sustainable energy systems, the energy transition, climate change, and clean energy programs. (Kalair et al., 2021) (Mbungu et al., 2020).

In the case of utilization of green and clean energy instead of non-renewable resources, the whole world is working on it right now. But compared with the world Bangladesh is doing nothing. From some research they just don't use it they store this energy and also transferring this in central grid system (Kumar & Jaipal, 2022) (Mbungu et al., 2020). The present scenario of using renewable energy in Bangladesh has been shown in Table 1 (Miskat et al., 2023).

Table 1: Bangladesh's current level of installed renewable energy capacity (MW) from various sources (National Database of Renewable Energy, 2023)

Techlology	Off-grid (MW)	On-grid (MW)	Total (MW)
Solar	365.88	595.39	961.27
Wind	2	0.9	2.9
Hydro	0	230	230
Biogas to Electricity	0.69	0	0.69
Biomass to Electricity	0.4	0	0.4
Total	**368.97**	**826.29**	**1195.26**

This research focuses on how to maintain a sustainable approach in an existing building to reduce energy and water use by using renewable energy. Economic and environmental growth are needed to use energy efficiently. The productivity of a structure depends on its placement and exposure, which let more sunlight in. A major energy waste is using electricity when the sun is out. New features can fix the issues, but they cost more. After accounting for the conventional energy system's greater costs, the adjustments are affordable. This ensures a B/C ratio above one and reasonable electricity savings. With the knowledge in this article, one can make informed judgments regarding greening an existing commercial building.

2 Materials and Methodology:

To facilitate comprehension, the technique has been divided into two categories. The first step is to determine where the building will be located and what type of structure it will be. The second phase is to assess the information required for the B/C ratio calculation, considering the building's adaptability to reduce energy and water consumption using renewable energy sources.

2.1 Selection of Study Area:

This is vital at the start of any research. The Dakbanglo, Khulna commercial structure is designated. Jalil Tower was chosen as a Bangladeshi commercial building reference owing to its congested surroundings and resemblance to most existing commercial structures in Bangladesh that demand sustainable growth without demolition. Bangladesh's business sector already uses sustainable building principles. However, certain town center structures had to be modified due to their high energy and water use. Jalil Tower in Dakbanglo, Khulna, is the commercial building benchmark due to these factors.

2.2 Assessment of Data:

Surveys determined the building's energy use and owner approval of the change. The main purpose of this survey was to see if the changes will allow long-term adaptations. We calculated the monthly utility costs by tracking each business's power and water use.

Solar panels will be installed on the roof to generate sustainable energy and reduce the building's energy consumption. Reflecting sunlight away from the roof keeps the building cooler and reduces air conditioner load.

After three months of rainy weather, the solar power system would not generate enough electricity to meet demand, therefore it would only be operational for nine months. Over these three months, the national power grid will meet all electrical demand at maximum capacity. These three months were overlooked for computing benefits and expenses because the two approaches are similar. The building owner and stakeholders have concluded debating renovations. They agreed to supervise the article's sources and evaluate its feasibility after that conversation.

The initial cost and prospective savings of solar panels have been calculated. These two figures yield the B/C ratio. Also included is the savings % for context.

3 Results and Analysis:

Tables 2, 3, and 4 have been calculated using equations presented in the Engineering Economy book (Leland & Anthony, 2005) and available online market prices.

Table 2. Expenditures for Conventional Energy System

Conventional System	
Initial cost	BDT
Maintenance Cost	54,000.00 BDT
Electricity Bill Every Year for 9 months	615,600.00 BDT
Increment in the bill per year	1%
Total Bill in 50 yr	30,475,247.52 BDT
Total Cost	30,529,247.52 BDT

Table 2 displays the total spending for the conventional energy system. Assuming that the facility was occupied for a total of 12 hours and that all its appliances were used for that duration, we may calculate the total cost. The average daily energy use for the structure is 190-kilowatt hours. The conventional method resulted in an annual electricity bill of 615,600 BDT. The total cost over the next 50 years is expected to be 30,529,248 BDT (an annual increase of 1%).

Table 3. Expenditure for Solar Power Systems

After Modification	
Initial cost	1,920,000.00 BDT
Maintenance Cost	3,894,000.00 BDT
Electricity Bill Every Year for 9 months	204,120.00 BDT
Increment in the bill per year	1%
Total Bill in 50 yr	10,104,950.50 BDT
Total Cost	15,918,950.50 BDT

Table 3 displays the cost of the solar power system for the building's renovation. A transformer is required to connect the solar panel to the national power infrastructure. As it already exists in the system as part of a conventional power system, the transformer requires only a maintenance cost of 54,000 BDT (considering a maintenance cost of 7,000 BDT every five years).

Table 4. B/C ratio and Cost Reduction

B/C and Reduction of Cost	
Benefits	30,529,247.52 BDT
Disbenefits	10,104,950.50 BDT
Costs	5,814,000.00 BDT
B/C	3.51
Costs saved from conventional power	14,610,297.03 BDT
Reduction of costs concerning conventional power	48%

Table 4 shows cost savings % and B/C ratio. The value of using the solar system is the benefits we obtain, not the cost of running a traditional system. 30 529 248 BDT are the rewards. The damage is 10,104,951 BDT per month from using electricity the solar system cannot deliver. Since the solar system only operates for nine hours and the building is occupied for twelve, it won't power it.
Thus, the B/C ratio formula: B/C means benefit-cost overall.
Project B/C is 3.51, which is greater than the one. Multiple initiatives could be done in the current context. Compared to the traditional system, the cost savings are 48%. This improvement cuts costs by 50%.
Please see the computation graphs below.

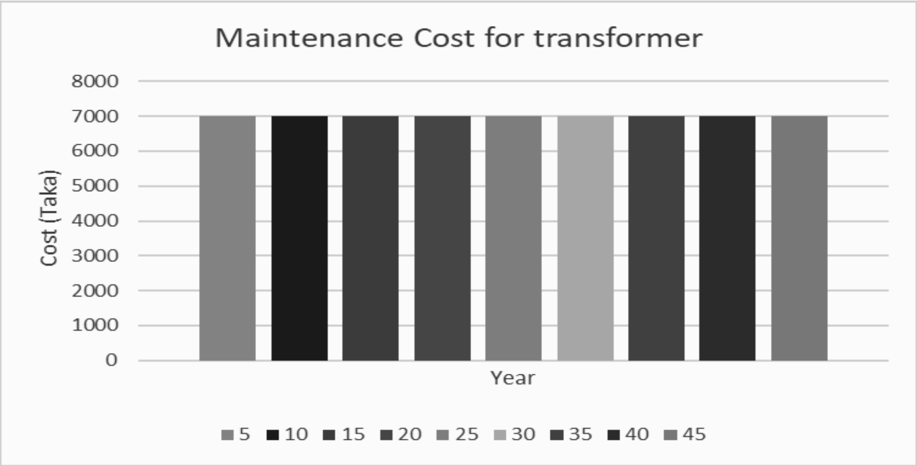

Figure 1. Maintenance Costs for Transformers

Figure 1 shows the estimated costs for the maintenance of transformers. These costs are included in both conventional power systems and solar power systems.

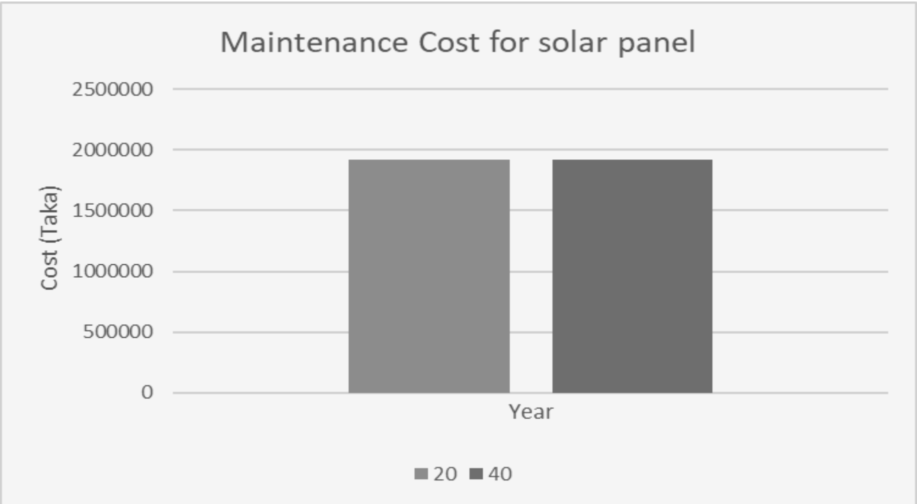

Figure 2. Maintenance Costs for Solar Panel.

Figure 2 shows the estimated costs for the maintenance of solar panels. These costs are only effective when a solar power system is used.

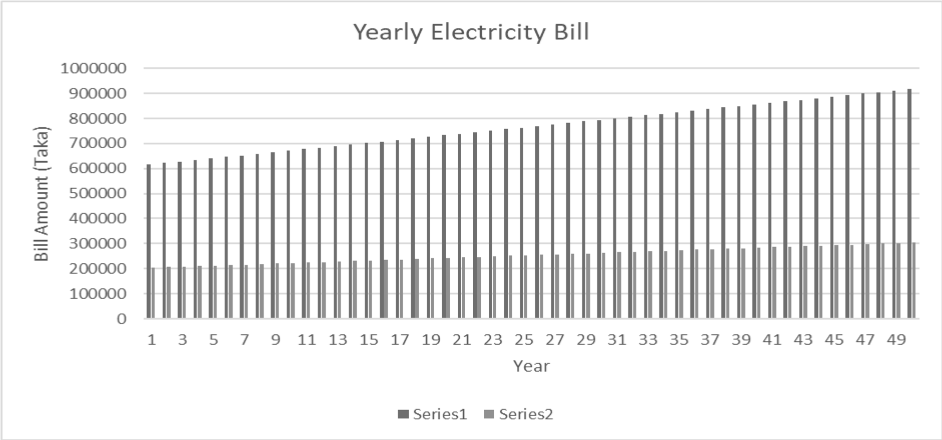

Figure 3. Estimated Electricity Bill

Figure 3 shows the estimated electricity bill that should be paid for both conventional and solar power systems. In the following Figure series, series 1 indicates the estimated electricity bill for a conventional power system, whereas series 2 indicates the estimated electricity bill for a solar power system.

4 Discussion

The Jalil Tower perfectly satisfies all requirements as a template for other commercial buildings across the country. To accomplish a sustainable commercial building, it’s necessary to discover a suitable alternative method for the reduction of nonrenewable energy for a better tomorrow. Though it may appear excessive at first sight, the initial cost will be reasonable in the long run. The responsible administration of a building's natural resources is essential to its sustainability. The alternative will reduce the strain on the country's primary energy system, which is predominantly comprised of fossil fuels, natural gas, and other similar sources and requires a substantial amount of water. If there is a decrease in the quantity of wasted energy, the system will operate more efficiently.

The most practical choice for the construction in question, after taking into account all relevant sustainability aspects, was solar energy. The owner opposes the design since it necessitates the closure of the stores for a time during construction, and the modification of the structure by replacing the brick wall with a glass wall may lead to structural problems. Contrarily, installing a solar power system does not need a lengthy shutdown of the building's operations or cause a loss of revenue.

The solar panel is used to implement the solar power system itself. These panels are extremely expensive from the outset. It does not require frequent maintenance, but whenever a problem occurs, the entire panel must be replaced. This significantly increases maintenance costs. Due to the panel's 15-year warranty, the total cost of maintenance will amount to 3,894,000 euros. As soon as the solar system is connected to the national grid, the cost of preventative maintenance for the transformers is added to the total price. The solar energy system has a nine-hour effective working time, but it must generate enough electricity to last for twelve hours. Due to this disparity, the solar energy system is connected to the national infrastructure. This endeavor is profitable because the modification resulted in a 48 percent cost reduction and a benefit-to-cost ratio greater than one.

This study is useful for the sustainable commercial building structure of a municipal area. The solar power system minimizes the consumption of natural resources, their waste, and carbon emissions by a factor of 10 by not using nonrenewable energy to generate electricity. This modification mechanism ensures the preservation of natural resources.

5 Conclusion

In the conventional system, the electricity bill for 50 years (the remaining 50-year lifespan of the building) is 30,475,248 BDT, whereas, after the modification, the electricity bill is 10,104,950 BDT. Thus, the bill decreased by approximately 67% compared to standard invoicing. Considering the initial cost of installing a solar power system, approximately 48% of expenses are saved over the next 50 years.

To determine the acceptability of the undertaking, the B/C ratio of 3.51 has been determined. Given that the ratio is greater than one, the endeavor is reasonable. Unconditionally, solar power systems can be used to make a building more environmentally friendly. The key finding of this study is the efficiency of renewable energy without wasting any natural resources and making the existing building more sustainable without any demolition or loss of productivity.

6 Recommendations

This study represents a preliminary idea that suggests efficient electricity management with minimal use of nonrenewable resources. There are many opportunities for further studies and better practical implementation. One can integrate this study with green building technology.
Based on theoretical research and the B/C ratio, this study offers an insightful recommendation that has advantages and shortcomings for use in a practical commercial building yet moves the process forward.

7 Acknowledgement

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